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Technical Attachment

Realtime Evaluation of WSR-88D Rainfall Estimates Using Stage II Rain Gauge Data in an Operational Environment.

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1. Introduction

Radar-derived estimates of precipitation are a potentially valuable source of real-time information for forecasters. However, one of the problems inherent in assessing the accuracy of rainfall estimates from all radar scan strategies is the lack of real-time ground truth from rain gauge observations. Forecasters need a way to determine real-time radar performance during a rain event. With Stage II radar data now routinely being processed by the River Forecast Centers (RFCs), forecasters now potentially have the ability to assess how well the radar is estimating rainfall. The question then involves how to get the Stage II information to the Weather Forecast Offices (WFOs) in a timely way.

WFO Lake Charles, working in cooperation with the Lower Mississippi RFC (LMRFC), has developed a way to view hourly bias data in AWIPS during a rain event. These data assist forecasters in determining which local radar, Fort Polk (KPOE) or Lake Charles (KLCH), has the best real-time sampling. Text files are alarmed at the appropriate work stations in the operations area. The text files contain six hours of radar bias data and can be viewed under the AWIPS product header BIAS. The text file also shows the number of gauge sites used in determining the Stage II data. By using such data, forecasters can better ascertain how well the radars are estimating rainfall.

As part of normal operating procedures, WFOs routinely complete a radar check that evaluates the mechanical and processing performance. However, this check does not assess radar performance versus ground truth rainfall. Having a tool to display the RFC bias data, can enhance the forecaster's ability to assess rainfall estimates.

2. Setup Procedures

At the RFC

The radar bias is generated at the RFC each hour by the Stage II program. That program compares the digital precipitation array one-hour rainfall estimates from individual radars to hourly rain gauge data. A bias is generated by comparing each rain gauge to the nearest 4 km grid point of hourly radar estimate. If the 4 km hourly radar estimate is above (below) the rain gauge estimate, a bias value is generated to decrease (increase) the radar estimate for that 4 km grid point. After each rain gauge has been compared to its nearest grid point, all of the radar/rain gauge bias values are averaged to produce a single composite radar bias that represents the entire 125 km radar umbrella. It is important to remember a radar bias can only be generated when at least four rain gauges report rainfall and the corresponding 4 km grid point from the radar indicates rainfall. If there are not 4 rain gauge/radar pairs, a bias from the previous hours will be used for the current hour.

The initial rainfall estimates from the radar have been assigned a bias of 1.00. After the Stage II analysis, the bias can change from 1.00 to some number above or below 1.00, or it can remain the same. The new bias value multiplies the hourly radar rainfall estimate at each 4 km grid. If the bias is above (below) 1.00, the radar rainfall estimates will be increased (decreased).

<u>At the WFO</u>

The radar bias program that we developed retrieves from the LMRFC the radar bias values and number of rain gauges used to calculate the radar bias. The program runs once an hour at the LMRFC and uses a simple SQL command to retrieve six hours of data from the Stage II result table in the Informix database. The data are output to an alphanumeric (ASCII) file and reformatted. The output file is then sent to the WFO using the "distributeProduct" program within AWIPS.

The RFC sends the bias data for each radar to the WFO AWIPS Data Server under the directory */data/x400/inbox/routine*. A Perl script reads the data from this directory, writes it to the Informix database and purges the old RFC data files. The Perl script in use at WFO Lake Charles is attached. It is a generic script that must be modified to run at another site. Below is an example of the text product BIAS viewable on the text workstation at the WFO.

Questions on this procedure can be directed to the WFO Lakes Charles ITO, Matthew Duplantis.

Sample AWIPS Text Workstation BIAS Product

```
radar   obstime               bias         precip_gages
POE     2002-06-14 10:00:00   0.78443265   88
POE     2002-06-14 11:00:00   0.78443265   93
POE     2002-06-14 12:00:00   0.78443265   68
POE     2002-06-14 13:00:00   0.78443265   40
POE     2002-06-14 14:00:00   0.78443265   29
POE     2002-06-14 15:00:00   0.78443265   0

HGX     2002-06-14 10:00:00   1.0233985    15
HGX     2002-06-14 11:00:00   1.0233985    15
HGX     2002-06-14 12:00:00   1.0233985    15
HGX     2002-06-14 13:00:00   1.0233985    14
HGX     2002-06-14 14:00:00   1.0233985    13
HGX     2002-06-14 15:00:00   1.0233985    0

LCH     2002-06-14 10:00:00   0.85484385   56
LCH     2002-06-14 11:00:00   0.85484385   58
LCH     2002-06-14 12:00:00   0.85484385   47
LCH     2002-06-14 13:00:00   0.85484385   31
LCH     2002-06-14 14:00:00   0.85484385   25
LCH     2002-06-14 15:00:00   0.85484385   0
```

To illustrate the use of the above information, assume the Fort Polk (KPOE) one-hour radar rainfall estimate at a given location is 2.0 inches. Applying the bias value above, that value should be reduced to 1.56 inches (0.78 x 2.0 = 1.56).

3. Results and Conclusions

Based on recent use of this automated process in AWIPS, Lake Charles forecasters determined that the KPOE radar was systematically underestimating precipitation amounts when the Continental Z-R relationship was used. Precipitation estimates from that radar improved after making the change to the Tropical Z-R relationship. The Stage II KPOE radar bias moved closer to 1.00, indicating that very little correction was needed between the radar-derived rainfall estimates and the ground truth rain gauge data. As a result of viewing bias information such as this, WFO Lake Charles is more apt to switch between Continental and Tropical Z-R relationships as the bias data suggest, to obtain better precipitation estimates from the radar.

When excessive rainfall is a threat, this tool can assist forecasters by allowing them to assess the radar's ability to properly translate the radar echoes to precipitation amounts, thereby increasing confidence in issuing Flash Flood Warnings when necessary. This tool has also proven reliable in helping the forecasters *refrain* from issuing a warning, even though strong radar echoes were detected.

Just as with forecast models, forecasters must understand the limitations of using automated Stage II data in AWIPS. Forecasters should remember the following points when applying the bias corrections:

1. BIAS data are saved until the next rain event or may default back to long term bias.
2. Precipitation values skewed by hail contamination.
3. Possible erroneous bias value due to rainfall not falling over rain gage sites.
4. Underestimates of precipitation due to winds.
5. Poor hourly rain gauge network.
6. Range limitation.
7. Poor calibration of the WSR-88D.
8. Bright banding, especially during the cool season.

There have been times when our radar bias readings have been as large as 1.86 for many hours. We found out that long term radar bias was being used. Long term bias is calculated over a 60-day period to develop an average computed bias for that radar, then displayed as the hourly bias. Conversely, short term radar bias is computed on a hourly basis. The long term bias was used because there was less than 4 radar/rain gauge pairs to generate a short term bias.

4. Suggested Reading

Several good papers outlining Stage II data issues can be found at the following Web sites:

http://www.srh.noaa.gov/lmrfc/papers/index.htm
http://www.srh.noaa.gov/wgrfc/projects/default.html
http://weather.gov/oh/hrl/papers/ams/ams98-1.htm
http://www.nws.noaa.gov/oh/hrl/papers/ams/ams98-1.htm

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Attachment

```
#! /usr/local/perl/bin/perl
#
# Author: Matthew Duplantis, LCH ITO (337) 477-3422
#
$file1_out=`ls -1 /data/x400/inbox/routine/ORN-* | tail -2 | head -1`; chomp $file1_out;
$file2_out=`ls -1 /data/x400/inbox/routine/ORN-* | tail -4 | head -1`; chomp $file2_out;
$file3_out=`ls -1 /data/x400/inbox/routine/ORN-* | tail -6 | head -1`; chomp $file3_out;
open(BIAS, "> /yourdatadirectory/BIAS");
                                        # example...yourdatadirectory = Choose your director
open(FILE1, "< $file1_out");
while(<FILE1>)
{
        chomp $_;
        if((/your Radar ID/) || (/other Radar Ids/))   # example... your Radar ID = KLCH
        {
                print BIAS "$_\n";
        }
}
close FILE1;
print BIAS "\n";
local( $storeCommand ) = "rm $file1_out";
system($storeCommand);
##########################################################################################
# Uncomment this section if there are multiple radars you wish to get bias data for.
#
##########################################################################################
#open(FILE2, "< $file2_out");
#while(<FILE2>)
#{
#       chomp $_;
#       if((/your Radar ID/) || (/other Radar IDs/))
#       {
#               print BIAS "$_\n";
#       }
#}
#close FILE2;
#
#local( $storeCommand ) = "rm $file2_out";
#system($storeCommand);
#
#print BIAS "\n";
#
#open(FILE3, "< $file3_out");
#while(<FILE3>)
#{
#       chomp $_;
#       if((/your Radar ID/) || (/other Radar IDs/))
#       {
#               print BIAS "$_\n";
#       }
#}
#close FILE3;
#close BIAS;
#
#local( $storeCommand ) = "rm $file3_out";
#system($storeCommand);
local( $storeCommand ) = "rm /data/x400/inbox/routine/ORN-*.doc";
system($storeCommand);
local( $storeCommand ) = "textdb -w YOURBIASPIL < /yourdatadirectory/BIAS";
                                        # example YOURBIASPIL = BIAS or whatever you choose
system($storeCommand);
exit;
```